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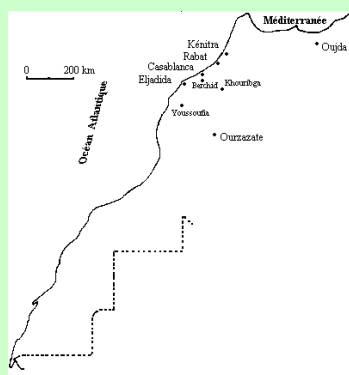
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Introduction

In this work, we report the results of experiments conducted to calibrate the used cellulose nitrate films LR-115 type II, the volumic activities measured by means of these films in some dwellings and enclosed work areas in Morocco and we give the calculated effective doses received by population exposed to the radon effects. Seasonal variation study of radon volumic activity and relationships between variation of this activity and some parameters such height, depth and type of construction are also discussed in this work.

Sampling sites.



Results and discussion

The measurements were performed in 9 dwellings and 7 enclosed work areas in some regions of Morocco. Results for dwellings are given in table 1 and these for enclosed work areas are given in table 2. The exposure period of films in dwellings and in enclosed work areas varied between 2 and 4 months. The given results are an average of at least 2 measures by locality and at least in two houses.

The effective dose per unit exposure to radon and radon progeny was obtained using the so-called dose conversion convention as defined by ICRP

Table 1: Volumic activities of ²²²Rn and effective doses in indoor dwellings

Town	Volumic activity of ²²² Rn (Bq/m ³)	Effective dose (mSv/year)
Berchid	76 ± 8	1.34 ± 0.14
Casablanca	31 ± 3	0.55 ± 0.05
El Jadida	47 ± 4	0.83 ± 0.07
Ouarzazate	99 ± 5	1.74 ± 0.09
Oujda	83 ± 7	1.46 ± 0.12
Rabat	64 ± 5	1.13 ± 0.09
Kénitra	59 ± 6	1.04 ± 0.11
Youssoufia	124 ± 8	2.18 ± 0.14
Khouribga	136 ± 9	2.39 ± 0.16

Table 2: Volumic activities of ²²²Rn and effective doses in enclosed work areas.

Enclosed work area	Volumic activity (Bq/m ³)	Effective dose (mSv/year)
Laboratory of nuclear physics (Rabat)	60 ± 4	0.38 ± 0.03
Local for practical nuclear studies (Faculty of Sciences, Rabat)	68 ± 6	0.43 ± 0.04
Factory 1	435 ± 4	2.74 ± 0.03
Factory 2	142 ± 15	0.90 ± 0.09
Geophysical Observatory of Berchid (Ground level)	63 ± 5	0.40 ± 0.03
Geophysical Observatory of Berchid (Cave at -12 meters)	1884 ± 199	11.90 ± 1.25

Activities of radon vary in Houses, between 31 and 136 Bq/m³ with an average value of 80 Bq/m³. This value is comparable to those found in the other regions of the world. In Enclosed work area, they vary between 60 Bq/m³ in an ordinary area to 1884 Bq/m³ at not airy underground level of 12 m.

The calculated effective dose in houses varies between 0.55 and 2.39 mSv/year with an average value of about 1.41 mSv/year. In enclosed areas it varies between 0.38 and 11.9 mSv/year with an average value of about 2.8 mSv/year. Thus the radon concentration levels found in this study are below the action level recommended by the ICRP.

The relationships between volumic activities of indoor radon and seasonal variations are given in table 3

Table 3: Seasonal variation study of Radon volumic activity

Exposition season	Volumic activity (Bq/m ³)
Summer	37 ± 2
Autumn	60 ± 4
Winter	95 ± 7
Spring	66 ± 4

the activity of the radon decreases with the height as in table 4.

Table 4: Radon volumic activities according to the height

floor	Volumic activity (Bq/m ³)
1 st	67
2 nd	54
3 th	47
4 th	32

Table 5: Radon volumic activities According to the depth

Depth	Volumic activity (Bq/m ³)
Ground Level	Office 58 ± 6 Room 68 ± 8
The cellar	1 st level (-4m) 1208 ± 184
	2 nd level (-8m) 1499 ± 100
	3 th level (-12m) 1884 ± 119

Conclusion

The obtained values of volumic activities of radon in dwellings and in enclosed work areas and the calculated effective dose are comparable to those obtained in the other regions in the world and they are below the action level recommended by the ICRP (3 to 10 mSv/year corresponding to volumic activities from 200 to 600 Bq/m³ for houses and from 500 to 1500 Bq/m³ for workplaces)

A maximal value of radon volumic activity was measured in winter and a minimal value of this activity was measured in summer.

The measured volumic activities of radon depend on some parameters such type of construction, the height of building and the depth of the underground.

The radon concentration levels found in this study are below the action level recommended by the ICRP.